PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Oji KUNO	Group Art Unit: 1754
Application No.: 10/661,596	Examiner: C. NGUYEN
Filed: September 15, 2003	Docket No.: 117167

For: CERIUM-ZIRCONIUM COMPOSITE METAL OXIDE

DECLARATION UNDER 37 C.F.R. §1.131

I, OJI KUNO, a citizen of Japan, hereby declare and state:

1. This Declaration is submitted as evidence that the subject matter claimed in the above-identified application was reduced to practice prior to May 13, 2003, the earliest U.S. filing date of U.S. Patent No. 6,956,008 ("Takeshima").

2. I am the named inventor of the above-identified application.

3. I am also the named inventor of the attached verified English translation of the Japanese Application JP 2002-81583, filed in Japan on March 22, 2002 (see Exhibit A attached to this Declaration).

4. Exhibit A describes a cerium-zirconium composite metal oxide, wherein a total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide, a molar ratio Ce/Zr is within a range from 1/9 to 9/1, and an isoelectric point of the composite metal oxide is more than 3.5. See at least claim 1 and paragraph [0007] of Exhibit A. Exhibit A further describes a cerium-zirconium composite metal oxide, wherein a total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide and CeO_2 forms a core surrounded by ZrO_2. See at least claim 4 and paragraph [0011] of Exhibit A.

5. Exhibit A thus supports the subject matter as claimed, and Exhibit A may be summarized as describing:

(a) a cerium-zirconium composite metal oxide, wherein a total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide, a molar ratio Ce/Zr is within a range from 1/9 to 9/1, and an isoelectric point of the composite metal oxide is more than 3.5; and

(b) a cerium-zirconium composite metal oxide, wherein a total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide and CeO_2 forms a core surrounded by ZrO_2.

6. Exhibit A describes an invention conceived and reduced to practice prior to May 13, 2003, and specifically at least by the March 22, 2002 filing date in Japan of JP 2002-81583.

7. Prior to May 13, 2003, I and/or those under my control and supervision carried out a reduction to practice of the invention described in Exhibit A and thereby provided a cerium-zirconium composite metal oxide as defined in the present claims.

8. I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine and/or imprisonment under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing therefrom.

Date: March 24, 2006

OJI KUNO

In re Patent Application of: Oji Kuno

Serial No. 10/661,596 Examiner: CAM N. NGUYEN
Filed: September 15, 2003 Group Art Unit: 1754
For: CERIUM-ZIRCONIUM COMPOSITE METAL OXIDE

TRANSLATOR'S DECLARATION

Honorable Commissioner of Patents & Trademarks
Washington, D.C. 20231

Sir:

I, Hisashi Nakamura , residing at c/o A. AOKI, ISHIDA & ASSOCIATES, Toranomon 37 Mori Bldg., 3-5-1, Toranomon Minato-ku, Tokyo 105-8423, Japan declare the following:

(1) That I know well both the Japanese and English languages;

(2) That I translated Japanese Patent Application No. 2002-81583 , filed March 22, 2002 , from the Japanese language to the English language;

(3) That the attached English translation is a true and correct translation of the aforesaid Japanese Patent Application No. 2002-81583 to the best of my knowledge and belief; and

(4) That all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

February 20, 2006
Date

[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] Cerium-Zirconium Composite Metal Oxide

[SCOPE OF CLAIM FOR PATENT]

[Claim 1] A cerium-zirconium composite metal oxide, characterized in that the total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide, a molar ratio Ce/Zr is within a range from 1/9 to 9/1, and an isoelectric point of the composite metal oxide is more than 3.5.

[Claim 2] The cerium-zirconium composite metal oxide according to claim 1, wherein the molar ratio Ce/Zr is within a range from 3/7 to 7/3 and the isoelectric point is within a range from 3.8 to 5.0.

[Claim 3] The cerium-zirconium composite metal oxide according to claim 1 or 2, which contains rare earth metal (excluding Ce) in a concentration of less than 15% by mole based on the total mole number of metal in the composite metal oxide.

[Claim 4] A cerium-zirconium composite metal oxide, characterized in that the total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide and CeO_2 forms a core surrounded by ZrO_2.

[Claim 5] The cerium-zirconium composite metal oxide according to claim 4, wherein the CeO_2 core has a diameter within a range from 5 to 20 nm.

[Claim 6] An exhaust gas purifying catalyst comprising the cerium-zirconium composite metal oxide of any one of claims 1 to 5 and a noble metal supported on the cerium-zirconium composite metal oxide.

[Claim 7] A method for synthesizing the cerium-zirconium composite metal oxide of any one of claims 1 or 4, which comprises mixing a ceria sol and a zirconium compound solution or a zirconia sol to prepare a suspension, and drying and firing the mixture.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to Which the Invention Pertains]

The present invention relates to a cerium-zirconium composite metal oxide and, more particularly, to a cerium-zirconium composite metal oxide which is suitable for use as a promoter for an exhaust gas purifying catalyst for an internal combustion engine.

[0002]

[Prior Art]

Exhaust gas emitted from an internal combustion engine such as an automobile engine includes such substances as nitrogen oxides (NOx), carbon monoxide (CO) and hydrocarbons (HC). These harmful substances can be neutralized by means of a three-way catalyst which oxidizes CO and HC and reduces NOx into O_2.

Such a three-way catalyst is generally composed of a support made of an oxide such as γ-alumina, and a catalyst component consisting of a noble metal such as platinum (Pt), palladium (Pd) or rhodium (Rh) supported on the support.

[0003]

In order for the oxidation of CO and HC and reduction of NOx to proceed efficiently on the three-way catalyst, it is necessary that the air-fuel ratio in the internal combustion engine is properly controlled and that the composition of the exhaust gas lies within a narrow, particular range. In reality, however, the composition of the exhaust gas experiences some variations due to such factor as a delay in the operation of a control system, and may deviate out of the above-mentioned narrow range.

[0004]

In a cerium-zirconium composite metal oxide, Ce atoms can change the valence thereof between 3 and 4. In an oxidizing atmosphere including a relatively large amount of O_2 the Ce atom changes the valence from 3 to 4 and absorbs oxygen, while in a reducing atmosphere containing a relatively large amount

of CO and HC the Ce atom changes the valence from 4 to 3 and releases oxygen, thus demonstrating an oxygen storage capacity (OSC).

Therefore, including the cerium-zirconium composite metal oxide in an exhaust gas purifying catalyst has an effect of mitigating the variations in the exhaust gas composition in the vicinity of catalyst component, thereby causing the purification of exhaust gas to proceed more efficiently.

[0005]

In addition, absorption of oxygen by the cerium-zirconium composite metal oxide is accompanied by the generation of a significant amount of heat, and the heat can be used to warm up the catalyst when starting up the engine, thus making it possible to shorten the time before the catalyst is activated. For this reason, the cerium-zirconium composite metal oxide is used as a promoter for an exhaust gas purifying catalyst.

Prior art related to the cerium-zirconium composite metal oxide includes those disclosed in Japanese Unexamined Patent Publication (Kokai) No. 10-194742 and in Japanese Unexamined Patent Publication (Kokai) No. 6-279027.

[0006]

[Problems to Be Solved by the Invention]

However, the cerium-zirconium composite metal oxide has a drawback that the oxygen storage capacity decreases after it has been exposed to a high temperature of about 1000°C or more for a long period of time, thus showing an insufficient durability.

Accordingly, an object of the present invention is to provide a cerium-zirconium composite metal oxide having improved durability at high temperature and showing a stable oxygen storage capacity.

[0007]

[Means for Solving the Problems]

The object described above can be achieved by a cerium-zirconium composite metal oxide characterized in that the total mole number of Ce and Zr is at least 85% based on the

total mole number of metal in the composite metal oxide, a molar ratio Ce/Zr is within a range from 1/9 to 9/1, and an isoelectric point of the composite metal oxide is more than 3.5.

[0008]

In other word, the present invention provides a cerium-zirconium composite metal oxide which has a specific composition and, especially, has an isoelectric point more than 3.5.

[0009]

The term "isoelectric point" is a characteristic value measured on the basis of electrophoresis of particles contained in a slurry, and the isoelectric point of CeO_2 is 2.4 and the isoelectric point of ZrO_2 is 4.0 according to a method specified in the present invention. Accordingly, the cerium-zirconium composite metal oxide of the present invention is characterized in that it has a value of isoelectric point near to that of ZrO_2 while containing both CeO_2 and ZrO_2.

[0010]

The cerium-zirconium composite metal oxide of the present invention has a value of the isoelectric point significantly higher than that of the cerium-zirconium composite metal oxide of the prior art which has similar proportions of CeO_2 and ZrO_2. An exhaust gas purifying catalyst which has Pt supported on such a cerium-zirconium composite metal oxide has durability significantly improved over that of the prior art.

[0011]

Based on these facts, it is considered that the cerium-zirconium composite metal oxide of the present invention has such a constitution as the constituent particles thereof are made mainly of ZrO_2 in the outer layer and mainly of CeO_2 inside, as shown in Fig. 1, and this constitution is stabilized when a trace of element selected from among rare earth metals coexists with ZrO_2.

In another aspect, the present invention provides a

cerium-zirconium composite metal oxide, characterized in that the total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide and CeO_2 forms a core surrounded by ZrO_2.

[0012]

When the particles of cerium-zirconium composite metal oxide are made of CeO_2 and ZrO_2 in such a constitution as described above, it is considered that ZrO_2 having high heat resistance maintains the form of particles of cerium-zirconium composite metal oxide so that CeO_2 existing inside and/or CeO_2 - ZrO_2 in the border region between the inside and the outer layer are made stable with time, thereby demonstrating the satisfactory oxygen storage capacity.

It is to be understood that Fig. 1 shows a mere model and is not intended to limit the present invention.

[0013]

[Mode for Carrying Out the Invention]

The present invention provides a cerium-zirconium composite metal oxide, characterized in that the total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide, a molar ratio Ce/Zr is within a range from 1/9 to 9/1, and an isoelectric point of the composite metal oxide is more than 3.5 and, more preferably, the molar ratio Ce/Zr is within a range from 3/7 to 7/3 and the isoelectric point is within a range from 3.8 to 5.0.

In the present invention, the isoelectric point is defined as a value measured by the stop watch method, a version of the electrophoretic microscope method specified in JIS R1638.

[0014]

The cerium-zirconium composite metal oxide refers to an oxide which contains at least Ce and Zr and may also contain another additional metallic element. The additional metallic element may be selected from among a wide range comprising s-block metals, d-block metals, p-block metals and f-block

metals, such as sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), barium (Ba), strontium (Sr), lanthanum (La), yttrium (Y), cerium (Ce), praseodymium (Pr), neodymium (Nd), samarium (Sm), europium (Eu), gadolinium (Gd), titanium (Ti), tin (Sn), zirconium (Zr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), chromium (Cr), niobium (Nb), copper (Cu), vanadium (V), molybdenum (Mo), tungsten (W), zinc (Zn), aluminum (Al), silicon (Si) and tantalum (Ta).

[0015]

The additional metallic element mentioned above is preferably at least one of rare earth metals such as La, Y, Ce, Pr, Nd, Sm, Eu and Gd, and is contained in a concentration less than 15% based on the total mole number of metal in the cerium-zirconium composite metal oxide.

When such a rare earth metal is used as the additional metallic element, it is considered that ZrO_2 which surrounds the core is especially stabilized.

[0016]

The cerium-zirconium composite metal oxide of such a constitution is preferably produced by using a ceria sol as a source of cerium and is obtained by mixing the ceria sol and a zirconium compound solution or a zirconia sol, and preferably a solution of a compound of the additional metallic element or a sol thereof in a predetermined proportion to prepare a suspension, and then drying and firing the suspension.

[0017]

The term "sol" in ceria sol and zirconia sol refers to colloid of an oxide or hydrate which is dispersed in a liquid, particularly in water, which can produce a metal oxide such as ceria or zirconia when fired. Specifically, the sol may be a material which is obtained by hydrolyzing alkoxide, acetylacetonato, acetate, nitrate or the like of such element as cerium or zirconium in a solution.

The zirconium compound solution may be, for example, an aqueous solution of zirconium oxynitrate $ZrO(NO_3)_2 \cdot 2H_2O$, zirconium oxide $ZrCl_4$ or the like.

[0018]

The material is fired, for example, in an air atmosphere at a temperature from 600 to 900°C for several hours. The cerium-zirconium composite metal oxide thus prepared is processed in a grinding process as required, and is provided with a noble metal such as platinum, palladium or rhodium supported thereon, thereby making the exhaust gas purifying catalyst.

The exhaust gas purifying catalyst can demonstrate high and stable exhaust gas purifying performance without degradation of the oxygen storage capacity even when exposed to a high temperature of about 1000°C.

The following Examples further illustrate the present invention.

[0019]

[Examples]

Example 1

A solution prepared by dissolving 41.16 g of zirconium oxynitrate and 6.48 g of yttrium nitrate in 100 g of ion-exchanged water was added to 193.33 g of a ceria sol (containing 15% by weight of Needral U-15, manufactured by TAKI CHEMICAL CO., LTD. as CeO_2) and stirred to prepare a uniform suspension.

The suspension was heated at 120°C for 24 hours to evaporate water, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide of the present invention having the following composition (weight ratio).

$CeO_2/ZrO_2/Y_2O_3$ = 58/38/4

[0020]

Then, 50 g of this composite metal oxide was dispersed in 300 g of ion-exchanged water to prepare a slurry. Then, 11.36 g of an aqueous solution of a diamminedinitroplatinum complex (Pt concentration: 4.4% by weight) was added to the slurry, followed by stirring for 2 hours.

The slurry was then heated at 120°C for 24 hours to evaporate water, and fired at 500°C for 2 hour to obtain an

exhaust gas purifying catalyst comprising a cerium-zirconium composite metal oxide of the present invention and 1% by weight of Pt supported on the cerium-zirconium composite metal oxide.

[0021]

Example 2

A solution prepared by dissolving 6.48 g of yttrium nitrate in 50 g of ion-exchanged water and 95 g of a zirconia sol (containing 20% by weight of Zirconia HA, manufactured by Daiichi Kigensokagaku Kogyo Co., Ltd. as ZrO_2) were added to 193.33 g of the ceria sol described above and stirred to prepare a uniform suspension.

[0022]

The suspension was heated to evaporate water in the same manner as in Example 1, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide having the following composition (weight ratio) of the present invention.

$CeO_2/ZrO_2/Y_2O_3$ = 58/38/4

Then, in the same manner as in Example 1, 1% by weight of Pt was supported on the composite metal oxide using the diamminedinitroplatinum complex to obtain an exhaust gas purifying catalyst of the present invention.

[0023]

Example 3

A solution prepared by dissolving 6.48 g of yttrium nitrate in 50 g of ion-exchanged water and 154.5 g of a zirconia sol (including 12.5% by weight of Zirconia AC7 manufactured by DAIICHI KIGENSO KAGAKU KOGYO CO., LTD. All as ZrO_2) were added to 193.33 g of the ceria sol described above and stirred to prepare a uniform suspension.

[0024]

The suspension was heated to evaporate water in the same manner as in Example 1, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide having the following composition (weight ratio) of the present invention.

$CeO_2/ZrO_2/Y_2O_3$ = 58/38/4

Then, in the same manner as in Example 1, 1% by weight of Pt was supported on the composite metal oxide using the diamminedinitroplatinum complex to obtain an exhaust gas purifying catalyst of the present invention.

[0025]

Example 4

A solution prepared by dissolving 34.66 g of zirconium oxynitrate, 3.99 g of lanthanum nitrate and 8.94 g of praseodymium nitrate in 300 g of ion-exchanged water was added to 193.33 g of the ceria sol described above and then stirred to prepare a uniform suspension.

[0026]

The suspension was heated to evaporate water in the same manner as in Example 1, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide having the following composition (weight ratio) of the present invention.

$CeO_2/ZrO_2/La_2O_3/Pr_6O_{11}$ = 58/32/3/7

Then, in the same manner as in Example 1, 1% by weight of Pt was supported on the composite metal oxide using the diamminedinitroplatinum complex to obtain an exhaust gas purifying catalyst of the present invention.

[0027]

Comparative Example 1

A solution was prepared by dissolving 73.165 g of cerium nitrate, 41.16 g of zirconium oxynitrate and 6.48 g of yttrium nitrate in 500 g of ion-exchanged water. Ammonia water having a concentration of 1 mole/liter was added dropwise to the solution to adjust the pH value to about 9, thereby to obtain a precipitate by coprecipitation.

[0028]

The solution containing the precipitate was heated to evaporate water in the same manner as in Example 1, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide having the following composition (weight ratio) of the Comparative Example.

$CeO_2/ZrO_2/Y_2O_3$ = 58/38/4

Then, in the same manner as in Example 1, 1% by weight of Pt was supported on the composite metal oxide using the diamminedinitroplatinum complex to obtain an exhaust gas purifying catalyst of the Comparative Example.

[0029]

Comparative Example 2

A solution was prepared by dissolving 73.17 g of cerium nitrate, 34.66 g of zirconium oxynitrate, 3.99 g of lanthanum nitrate and 8.94 g of praseodymium nitrate in 500 g of ion-exchanged water.

A precipitate was produced from the solution by coprecipitation to evaporate water in the same manner as in Example 1, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide having the following composition (weight ratio) of the Comparative Example.

$CeO_2/ZrO_2/La_2O_3/Pr_6O_{11}$ = 58/32/3/7

Then, in the same manner as in Example 1, 1% by weight of Pt was supported on the composite metal oxide using the diamminedinitroplatinum complex to obtain an exhaust gas purifying catalyst of the Comparative Example.

[0030]

Comparative Example 3

29 g of cerium oxide powder was dispersed in 500 g of ion-exchanged water, and then a solution prepared by dissolving 41.16 g of zirconium oxynitrate and 6.48 g of yttrium nitrate in 200 g of ion-exchanged water was added dropwise and stirred to prepare a slurry.

Ammonia water was added dropwise to the slurry to adjust the pH value to about 9 in the same manner as in Comparative Example 1 to produce a precipitate containing zirconium and yttrium.

[0031]

The slurry was heated to evaporate water, and then fired at 700°C for 5 hours to obtain a cerium-zirconium composite metal oxide having the following composition (weight ratio) of the Comparative Example.

$CeO_2/ZrO_2/Y_2O_3$ = 58/38/4

Then, in the same manner as in Comparative Example 1, 1% by weight of Pt was supported on the composite metal oxide using the diamminedinitroplatinum complex to obtain an exhaust gas purifying catalyst of the Comparative Example.

[0032]

Measurement of isoelectric point

Values of isoelectric point of the samples of cerium-zirconium composite metal oxide produced in Examples 1 to 4 and Comparative Examples 1 to 3 were measured by the stop watch method, a version of the electrophoretic microscope method specified in JIS R1638. The results are summarized in Table 1.

A relationship between the pH and the zeta potential measured so as to determine the isoelectric point by the measuring method described above for the cerium-zirconium composite metal oxide of Example 1 and Comparative Example 1, CeO_2 powder and ZrO_2 powder are shown in Fig. 2.

[0033]

These results show a clear difference in the isoelectric point of the cerium-zirconium composite metal oxide between the Examples and the Comparative Examples. The Examples showed isoelectric points near that of ZrO_2 powder, while the Comparative Examples showed isoelectric points near that of CeO_2 powder.

As the compositions of the cerium-zirconium composite metal oxide were the same between Examples 1 to 3 and Comparative Examples 1 and 3, and Example 4 and Comparative Example 2, the difference described above is considered to be attributed to the form of CeO_2 and ZrO_2. It is believed that the Examples showed the isoelectric point near that of ZrO_2 powder since the cores made of CeO_2 are surrounded by ZrO_2 in the Examples as shown in Fig. 1.

[0034]

Evaluation of catalyst performances

The samples of cerium-zirconium composite metal oxide

made in Examples 1 to 4 and Comparative Examples 1 to 3 were compressed and crushed to make pellets about 2 mm in diameter. About 2.0 g of each of the samples was taken and tested to evaluate catalyst performances.

The exhaust gas purifying catalysts were fired at 1000°C for 3 hours for the purpose of comparing the durability, before the evaluation of catalyst performances.

[0035]

Evaluation test was conducted by measuring the rate of neutralizing the components C_3O_6 (HC), NO and CO while raising the catalyst bed temperature at a rate of 10°C /minute up to 400°C, and changing between carbon rich gas and lean gas having compositions shown in Table 1 at intervals of one minute, so that any difference in the oxygen storage capacity can be observed distinctly. The catalytic performances were evaluated in terms of the temperature at which 50% of the component was neutralized. The test results are summarized in Table 2.

[0036]

[Effect of the Invention]

The present invention can provide a cerium-zirconium composite metal oxide having improved durability at high temperature and showing a stable oxygen storage capacity.

[0037]

(Table 1) Gas composition for evaluation

	N_2 (%)	CO_2 (%)	NO (ppm)	CO (%)	C_3H_6 (ppmC)	H_2 (%)	O_2 (%)	H_2O (%)
Rich gas	Balance	10	2200	2.80	2500	0.27	0.77	10
Lean gas	Balance	10	2200	0.81	2500	0	1.7	10

[0038]

(Table 2) Results of the measurement of catalyst performances and isoelectric point

	Composition	Weight ratio	HC	NO	CO	Isoelectric point
Example 1	Ce-Zr-Y-O	58/38/4	234	266	180	4.2
Example 2	Ce-Zr-Y-O	58/38/4	253	286	221	3.9
Example 3	Ce-Zr-Y-O	58/38/4	263	301	216	4.1
Example 4	Ce-Zr-La-Pr-O	58/32/3/7	245	270	201	4.0
Comparative Example 1	Ce-Zr-Y-O	58/38/4	280	308	242	2.5
Comparative Example 2	Ce-Zr-La-Pr-O	58/32/3/7	269	303	253	2.2
Comparative Example 3	Ce-Zr-Y-O	58/38/4	302	366	299	3.3

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] A model of a cerium-zirconium composite metal oxide of the present invention.

[Fig. 2] A graph showing a relationship between the pH and the zeta potential in the measurement of an isoelectric point.

[NAME OF DOCUMENT] ABSTRACT
[Abstract]
[Problem]

To provide a cerium-zirconium composite metal oxide having improved durability at high temperature and showing a stable oxygen storage capacity.

[Means for Solving the Problems]

A cerium-zirconium composite metal oxide having improved durability at high temperature and a stable oxygen storage capacity is provided. The cerium-zirconium composite metal oxide is characterized in that the total mole number of Ce and Zr is at least 85% based on the total mole number of metal in the composite metal oxide, a molar ratio Ce/Zr is within a range from 1/9 to 9/1, and an isoelectric point of the composite metal oxide is more than 3.5. Preferably, the molar ratio Ce/Zr is within a range from 3/7 to 7/3 and the isoelectric point is within a range from 3.8 to 5.0, and the cerium-zirconium composite metal oxide contains a rare earth metal (excluding Ce) in a concentration of less than 15% by mole based on the total mole number of metal in the composite metal oxide. Also the present invention provides a cerium-zirconium composite metal oxide, characterized in that CeO_2 forms a core surrounded by ZrO_2.

[Representative Drawing] Fig. 2

Fig.1

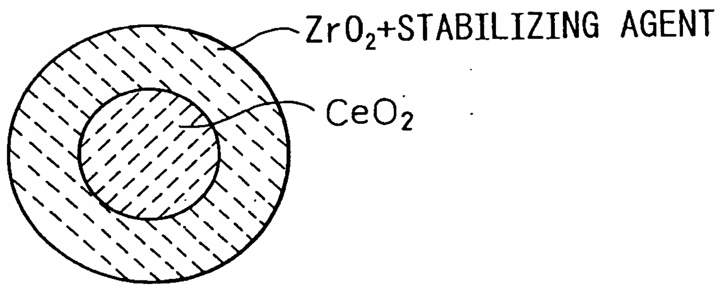

Fig.2

RELATIONSHIP BETWEEN pH AND ZETA POTENTIAL